

Chapter 4.0 Section 406 of the Clean Air Act Amendments: Industrial SO₂ Emissions

This chapter discusses the impact of industrial sulfur dioxide (SO₂) emissions, the source categories comprising industrial emissions, base year emissions development, projected emissions methodology, long-term emission trends, and desulfurization of diesel fuel benefits.

4.1 WHY A SEPARATE CHAPTER FOR INDUSTRIAL SO₂ EMISSIONS?

The major health effects associated with high exposures to SO₂ in the ambient air include problems in breathing, respiratory illness, alterations in the lung's defenses, and aggravation of existing respiratory and cardiovascular disease. People most sensitive to SO₂ include asthmatics and individuals with chronic lung disease (such as bronchitis or emphysema) or cardiovascular disease. Children and the elderly may also be sensitive.

SO₂ also produces foliar damage on trees and agricultural crops. SO₂ and nitrogen oxides (NO_x) in the air cause acidic deposition, commonly known as acid rain. Acid rain is associated with a number of effects including acidification of lakes and streams, damage to high-elevation forests, and accelerated corrosion of buildings and monuments. SO₂ and NO_x emissions also form sulfates and nitrates in the atmosphere that can significantly impair visibility.

This chapter provides information required under section 406 of the Clean Air Act Amendments (CAAA) of 1990 (42 U.S.C. 7651 note), which deals with SO₂ emissions from industrial sources. Section 406(a) states that:

Not later than January 1, 1995 and every 5 years thereafter, the Administrator of the Environmental Protection Agency shall transmit to the Congress a report containing an inventory of national annual sulfur dioxide emissions from industrial sources (as defined in title IV of the Act), including units subject to section 405(g)(6) of the Clean Air Act, for all years for which data are available, as well as the likely trend in such emissions over the following 20-year period. The reports shall also contain estimates

of the actual emission reduction in each year resulting from promulgation of the diesel fuel desulfurization regulations under section 214.

As discussed below, the United States (U.S.) Environmental Protection Agency (EPA) intends this chapter to provide the information required in section 406(a).

4.1.1 What Source Categories Are Industrial Sources?

Several provisions of the CAA and the CAAA address what source categories are industrial sources. Section 402(24) of the CAA defines industrial sources. An industrial source is:

a unit that does not serve a generator that produces electricity, a "nonutility unit" as defined in this section, or a process source as defined in section 410(e).

Further, section 406(a) of the CAAA of 1990 states that "industrial sources" include units subject to section 405(g)(6) of the CAA. (EPA believes that the reference in section 406(b) to section 405(g)(5) is erroneous and reads if as referring to section 405(g)(6).) Section 405(g)(6) of the CAA excludes from the Acid Rain Program under Title IV of the CAA certain "qualifying small power production facilit[ies]," "qualifying cogeneration facilit[ies]," and "independent power production facilit[ies]."

In order to determine the scope of the term "industrial source," it is necessary to consider several other statutory and regulatory definitions and provisions. Section 402(15) of the CAA defines "unit" as a "fossil fuel-fired combustion device." Section 72.2 of the regulations implementing Title IV of the CAA defines "fossil-fuel fired" as combusting "fossil fuel or any derivative of fossil fuel alone or in combination with any other fuel, independent of the percentage of fossil fuel consumed in any calendar year." Section 402(17)(A) of the CAA provides that a "utility unit" is, with certain exceptions (e.g., for certain cogeneration units under section 402(17)(C)),

any unit that “serves a generator in any State that produces electricity for sale” or that, “during 1985, served a generator in any State that produced electricity for sale.”

The categories of “industrial sources” referred to in section 406(a) of the CAAA of 1990 must be considered in light of these definitions and provisions. With regard to the category of “nonutility units,” section 402(25) of the CAA defines a “nonutility unit” as “a unit other than a utility unit.” This category comprises all stationary combustion devices that burn any fossil fuel and that are not affected units under the Acid Rain Program in Title IV of the CAA. Because the definition of this category excludes units that are utility units and, except for nonutility units that opt into the Acid Rain Program under section 410 of the CAA, only utility units are affected units, the category does not generally include any affected units.

For similar reasons, the next category of industrial sources, i.e., “units that do not serve a generator that produces electricity,” excludes all utility units and thus generally excludes all affected units under the Acid Rain Program in Title IV of the CAA. However, there are some units that are not affected units under the Acid Rain Program (e.g., units in Alaska and Hawaii and certain cogeneration units under section 402(17)(C)) but that do serve a generator that produces electricity. Therefore, this category of industrial sources is smaller than the “nonutility unit” category and excludes some stationary fossil-fuel fired combustion devices that are not affected units.

Another category of industrial sources (i.e., “process sources”) is not defined in Title IV of the CAA. Section 410(d) refers to “process sources” but does not define the term. For the purposes of this chapter, a process source is any source that emits SO₂ as the result of a production or manufacturing process and not as the result of any type of fuel combustion.

The last category of industrial sources comprises units that are utility units but that are exempt from the Acid Rain Program under section 405(g)(6) of the CAA. This includes certain “qualifying small power production facilities” or “qualifying cogeneration facilities” under section 3(17)(C) or 3(18)(B) of the Federal Power Act and certain “independent power production facilities” under section 416(a)(2)(A), (B), and (D) of the CAA. These terms are defined in section 72.2 of the regulations implementing the Acid Rain Program.

Finally, for purposes of applying the 5.60 million ton annual cap for SO₂ emissions from industrial sources, which is specified in section 406(b) of the CAAA of 1990, commercial/institutional/residential sources are excluded. This is because the 5.60 million ton cap was developed using emissions in the 1985 National Acid Precipitation Assessment Program NAPAP¹ inventory that cover sources involving industrial combustion and industrial/manufacturing processes and do not cover commercial/institutional/residential sources. Commercial/institutional/residential sources encompass combustion sources, such as those located at hospitals,

universities, or residences, that are not related to the production of physical products.

In summary, industrial sources covered by the 5.60 million ton annual cap include: all stationary fossil-fuel fired combustion devices, except for affected utility units under the Acid Rain Program and except for commercial/institutional/residential sources; and all process sources.

Table 4.1 presents the source categories defined as industrial sources.

4.2 WHY USE 1996 AS THE BASE YEAR?

Section 406 of the CAAA of 1990 specifies a 5.60 million ton cap on SO₂ emissions from industrial sources. Congress derived the cap from industrial source emission estimates developed as part of the 1985 NAPAP inventory. The 1990 National Emission Trends inventory (now called the “NET inventory”), developed from the 1985 NAPAP inventory, served as the baseline for the previous industrial SO₂ emission projections presented in the report “National Annual Industrial Sulfur Dioxide Emission Trends, 1995-2015: Report to Congress.”² Since that report, EPA, along with State and local agencies, revised the emission inventory for two separate time periods for different purposes. The most recent effort by EPA was the incorporation of 1996 Periodic Emission Inventories (PEI) into the NET inventory. (Refer to Section 5.6 for discussions on the PEI).

Since the 1996 NET inventory contains the most recent comprehensive emissions inventory, EPA chose it for the baseline for the industrial SO₂ emission estimates in this chapter. Table 4.2 presents the source of base year data for each of the 48 contiguous States. Thirty states provided 1996 point source emission inventories to the EPA, and 12 states provided acceptable 1996 area source emission inventories. The emissions for Oregon are from the Grand Canyon Visibility Transport Commission (GCVTC) 1990 inventory. The point source emissions for 7 other States and the area source emissions for 16 other States are estimated from the Ozone Transport Assessment Group (OTAG) 1990 inventory. The emission estimates for Alaska and Hawaii point sources are from multi-year Aerometric Information Retrieval System/AIRS Facility Subsystem (AIRS/AFS) retrievals, and EPA has never sent these estimates to these States for review. EPA estimated the area source emissions for Alaska and Hawaii. The remaining emissions are from the 1985 NAPAP inventory.

For States that did not provide EPA with a 1996 complete inventory, EPA estimated their emissions for 1996 using Bureau of Economic Analysis (BEA) growth factors. EPA did not assume any new controls nor plant retirements for these sources. More details on the methodology to estimate 1985 to 1996 emissions can be found in the NET inventory procedures document.³

Figure 4.1 presents the SO₂ industrial source emissions by major source categories for the year 1996. Fuel combustion sources are the largest contributors to industrial SO₂ emissions.

4.3 HOW DID EPA PROJECT EMISSIONS?

In addition to a national inventory of SO₂ emissions, section 406 of the CAAA of 1990 also calls for presentation of the likely trend in such emissions over the following 20-year period. Thus, Congress requires EPA to estimate future industrial source SO₂ emissions under section 406. Although section 406 calls for development of the likely trend in emission for a 20-year period, EPA developed emission estimates from 1996 (the base year) to 2020 since 2020 represents 20 years from the completion date of this report.

EPA considered fuel switching, energy efficiency (the amount of energy saved from the use of more efficient processes through time), and economic growth in the development of these projections. In general, less fuel will be needed to provide the same amount of energy (in the form of steam) to an industrial process and the amount of energy needed per unit output will also decrease as processes become more efficient. Fuel switching and energy efficiency are reflected in energy correction factors based on information obtained from the U.S. Department of Energy (DOE) publication Annual Energy Outlook 1997. Economic growth factors were derived from the 1995 BEA Gross State Product (GSP) projections by 2-digit Standard Industrial Classification (SIC) code. These were applied to estimate changes in activity between 1996 and 2030.⁴ For the purposes of satisfying section 406 requirements, a value was needed on 3-year intervals through 2020. Therefore, projections were calculated by applying growth ratios among existing sources to their base year emissions (1996). Interpolated factors were then applied to these same categories to estimate the every 3-year trend.

Further analysis of the 20-year projection is currently underway at EPA and results will be reported in the next Trends Report (planned for January 2001 publication).

4.4 WHAT IS THE TREND IN INDUSTRIAL SO₂ EMISSIONS?

Figure 4.2 presents the estimated trends in industrial source SO₂ emissions from 1900 to 2020. Table 4.3 presents the emissions by source category for every 3 years starting with 1996. The year 2007 is also displayed. The subcategories for solvent utilization and storage and transport are not displayed since these emissions are very small.

The emission estimates for the base year 1996 are 4.4 million short tons. The emission estimates show the industrial SO₂ emissions increasing steadily with the 20-year rate at approximately 8 percent. Fuel combustion sources continue

to be the largest contributor to industrial SO₂ emissions. The emission estimates show the fuel combustion emissions declining through the years, primarily from the result of energy efficiency factors. The largest increase in SO₂ can be seen in chemical and allied manufacturing, which is projected to rise 30 percent in the 20-year period. Total industrial source SO₂ emissions are currently projected to be approximately 4.7 million tons in 2020. Refer to Figure 4-3 for a graphical presentation of each category's 2020 contribution.

4.4.1 Will the Cap Be Exceeded?

Section 406(b) of the CAAA of 1990 states:

Whenever the inventory required by this section indicates that sulfur dioxide emissions from industrial sources, including units subject to section 405(g)(6) of the [CAA], may reasonably be expected to reach levels greater than 5.60 million tons per year, the Administrator of the [EPA] shall take such actions under the [CAA] as may be appropriate to ensure that such emissions do not exceed 5.60 million tons per year. Such actions may include the promulgation of new and revised standards of performance for new sources, including units subject to section 405(g)(6) of the [CAA], under section 111(b) of the [CAA], as well as promulgation of standards of performance for existing sources, including units subject to section 405(g)(5) of the [CAA], under authority of this section.

(As noted above, the reference to section 405(g)(5) should be to section 405(g)(6).)

The current emission estimates indicate that emissions of SO₂ from industrial sources will not exceed the 5.6 million tons per year cap through the year 2020. As stated earlier, more refinement of these estimates is ongoing and a revised projection will be released with the publication of the next Trends report.

4.5 WHAT ARE THE BENEFITS FROM DESULFURIZATION OF DIESEL FUELS?

Section 406(a) of the CAAA of 1990 also requires that EPA provide to Congress a report that contains estimates of the actual emission reduction in each year resulting from promulgation of the diesel fuel desulfurization regulations under section 214. As a result of the regulation, industry reduced the sulfur content of diesel fuel 0.25 to 0.05 percent as of October 1, 1993. Figure 4.4 displays the emissions for on-road sources with and without desulfurization. As shown, emission reductions in the year 1993 are smaller than the other years since industry lowered the sulfur content of the

fuel in October of that year. For the years 1994 through 1998, Figure 4.4 shows a 51 percent decrease in total vehicle emissions and a 400 percent decrease in diesel vehicle emissions, relative to what emissions would be without the fuel desulfurization program.

4.5.1 Why Are Current 1993 Emissions Without Desulfurization Higher Than the Values Presented in the 1995 Report to Congress?

The 1993 emissions for on-road vehicles without desulfurization differs from similar values presented in the “National Annual Industrial Sulfur Dioxide Emission Trends, 1995-2015: Report to Congress.” EPA generated the values in the previous report prior to the release of its PART5 emissions model, which EPA currently uses to generate SO₂ emissions from on-road sources.

For all estimates prior to October 1, 1993, the previous calculation assumed a sulfur content of 0.20 instead of 0.25 percent, since the 0.20 value was the default value listed in EPA’s AP-42 Emission Factor document.⁵ When PART5 was released, the default value was changed to 0.25. However, past October 1, 1993, the default value was changed to 0.05, since 0.05 is the regulatory value:

<i>Sulfur Content</i>	<i>Year reflected in data</i>
0.20 (1995 Report)	Pre October 1, 1993
0.25 (This Report)	Pre October 1, 1993
0.05 (This Report)	All years after October 1, 1993

4.6 REFERENCES

1. “The 1985 NAPAP Emissions Inventory (Version 2): Development of the Annual Data and Modelers’ Tapes.” EPA-600/7-89-012a, Air and Energy Engineering Research Laboratory, U.S. Environmental Protection Agency, Research Triangle Park, NC 27711.
2. “National Annual Industrial Sulfur Dioxide Emission Trends, 1995-2015: Report to Congress.” EPA-454/R-95-001. Office of Air and Radiation, U.S. Environmental Protection Agency, Research Triangle Park, NC. June 1995.
3. “National Air Pollutant Emission Trends Procedures Document, 1900-1996.” EPA-454/R-98-008. Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. May 1998.
4. “Procedures for Developing Base Year and Future Year Mass and Modeling Inventories for the Tier 2 Final Rulemaking,” EPA-420-R-99-034, September, 1999 (found on the web at: <http://www.epa.gov/otaq/tr2home.htm#tsd>).
5. “Compilation of Air Pollutant Emission Factors, Volume I: Stationary Point and Area Sources,” 4th Edition, Supplement D through 5th Edition, Supplement B, AP-42. U.S. Environmental Protection Agency, Research Triangle Park, NC. 1997.

Table 4-1. Industrial SO₂ Tier Source Categories

Description			Description		
Tier1	Tier2	Tier3	Tier1	Tier2	Tier3
FUEL COMB. INDUSTRIAL			OTHER INDUSTRIAL PROCESSES		
	Coal				Agriculture, Food, & Kindred Products
		bituminous			Textiles, Leather, & Apparel Products
		subbituminous			Wood, Pulp & Paper, & Publishing Products
		anthracite and lignite			Rubber & Miscellaneous Plastic Products
		other			Mineral Products
	Oil			cement mfg	
		residual		other	
		distillate			Machinery Products
		other			Electronic Equipment
	Gas				Transportation Equipment
	Other				Construction
	Internal Combustion				Miscellaneous Industrial Processes
CHEMICAL & ALLIED PRODUCT MFG			SOLVENT UTILIZATION		
		Organic Chemical Mfg			Degreasing
		Inorganic Chemical Mfg			Graphic Arts
		sulfur compounds			Dry Cleaning
		other			Surface Coating
		Polymer & Resin Mfg			Other Industrial
		Agricultural Chemical Mfg			Nonindustrial
		Paint, Varnish, Lacquer, Enamel Mfg			Solvent Utilization NEC
		Pharmaceutical Mfg	STORAGE & TRANSPORT		
		Other Chemical Mfg			Bulk Terminals & Plants
METALS PROCESSING					Petroleum & Petroleum Product Storage
		Non-Ferrous Metals Processing			Petroleum & Petroleum Product Transport
		copper			Service Stations: Stage I
		lead			Service Stations: Stage II
		aluminum			Service Stations: Breathing & Emptying
		other			Organic Chemical Storage
		Ferrous Metals Processing			Organic Chemical Transport
		Metals Processing NEC			Inorganic Chemical Storage
PETROLEUM & RELATED INDUSTRIES					Inorganic Chemical Transport
		Oil & Gas Production			Bulk Materials Storage
		natural gas			Bulk Materials Transport
		other	WASTE DISPOSAL & RECYCLING		
		Petroleum Refineries & Related Industries			Incineration
		fluid catalytic cracking units			industrial
		other			Open Burning
		Asphalt Manufacturing			industrial
					Industrial Waste Water
					TSDf
					industrial
					Landfills
					industrial

Table 4-2. Industrial SO₂ Point and Area Data Source Submittals by States

State	1996 PEI Point	1996 PEI Area	1990 OTAG Point	1990 OTAG Area	1985 NAPAP Point	1985 NAPAP Area	State	1996 PEI Point	1996 PEI Area	1990 OTAG Point	1990 OTAG Area	1985 NAPAP Point	1985 NAPAP Area
Alabama ¹	X	X					Nebraska	X					X
Arizona					X	X	Nevada					X	X
Arkansas ²			X			X	New Hampshire	X			X		
California	X	X					New Jersey			X	X		
Colorado	X					X	New Mexico					X	X
Connecticut	X	X					New York			X	X		
Delaware	X	X					North Carolina	X			X		
Florida	X			X			North Dakota	X					X
Georgia ¹	X	X					Ohio			X	X		
Idaho ²					X	X	Oklahoma	X	X				
Illinois	X			X			Oregon ³						
Indiana	X	X					Pennsylvania ^{1,2}	X			X		
Iowa					X	X	Rhode Island			X	X		
Kansas	X					X	South Carolina	X					X
Kentucky	X			X			South Dakota	X					X
Louisiana	X	X					Tennessee			X	X		
Maine	X			X			Texas	X	X				
Maryland	X	X					Utah ²					X	X
Massachusetts	X					X	Vermont	X			X		
Michigan	X			X			Virginia	X	X				
Minnesota			X			X	Washington	X	X				
Mississippi					X	X	West Virginia	X			X		
Missouri ¹	X	X					Wisconsin	X			X		
Montana	X					X	Wyoming					X	X

NOTE(S): 1: Only Partial State. See Tables 5.2 and 5.3 for more details.

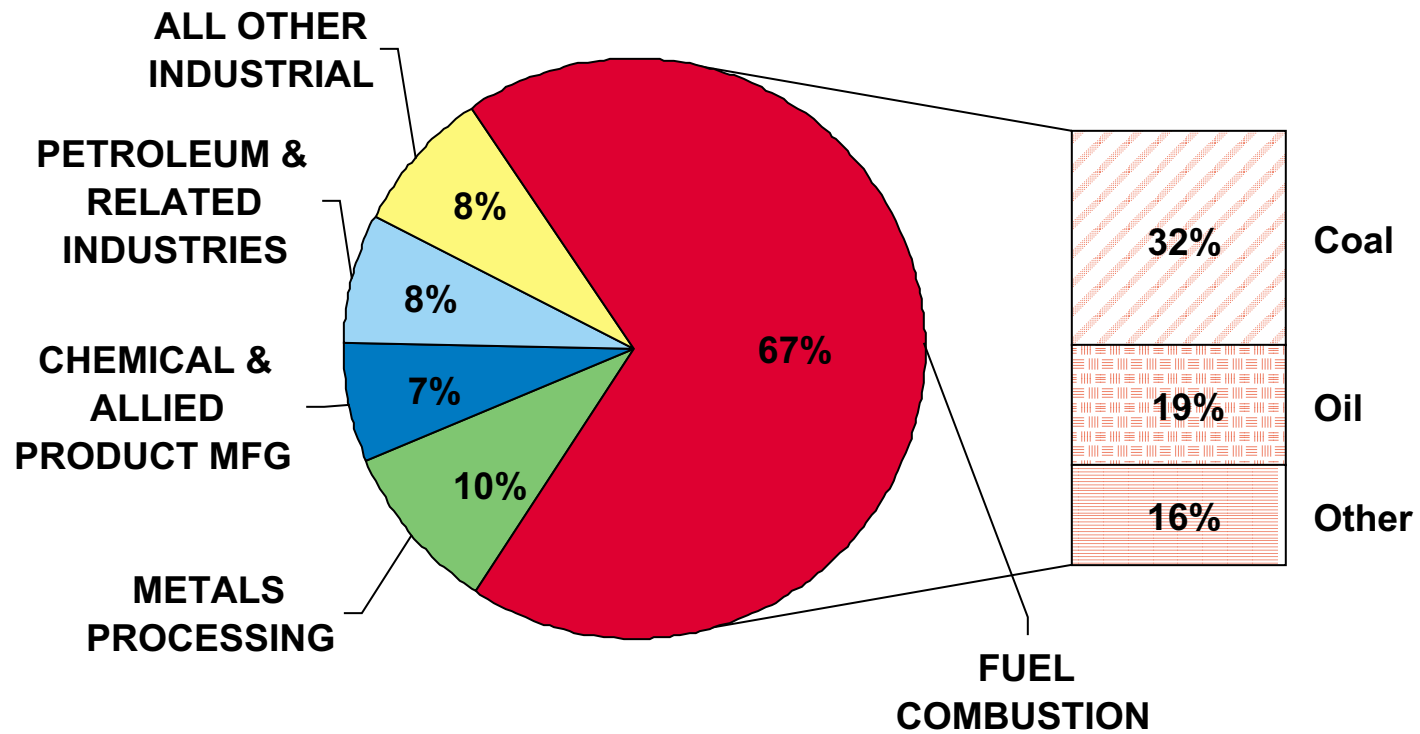
2: PEI data submitted but not incorporated into NET inventory due to programming or timing difficulties. Data to be incorporated in FY 2000.

3: Data obtained from 1990 Grand Canyon Visibility Transport Commission

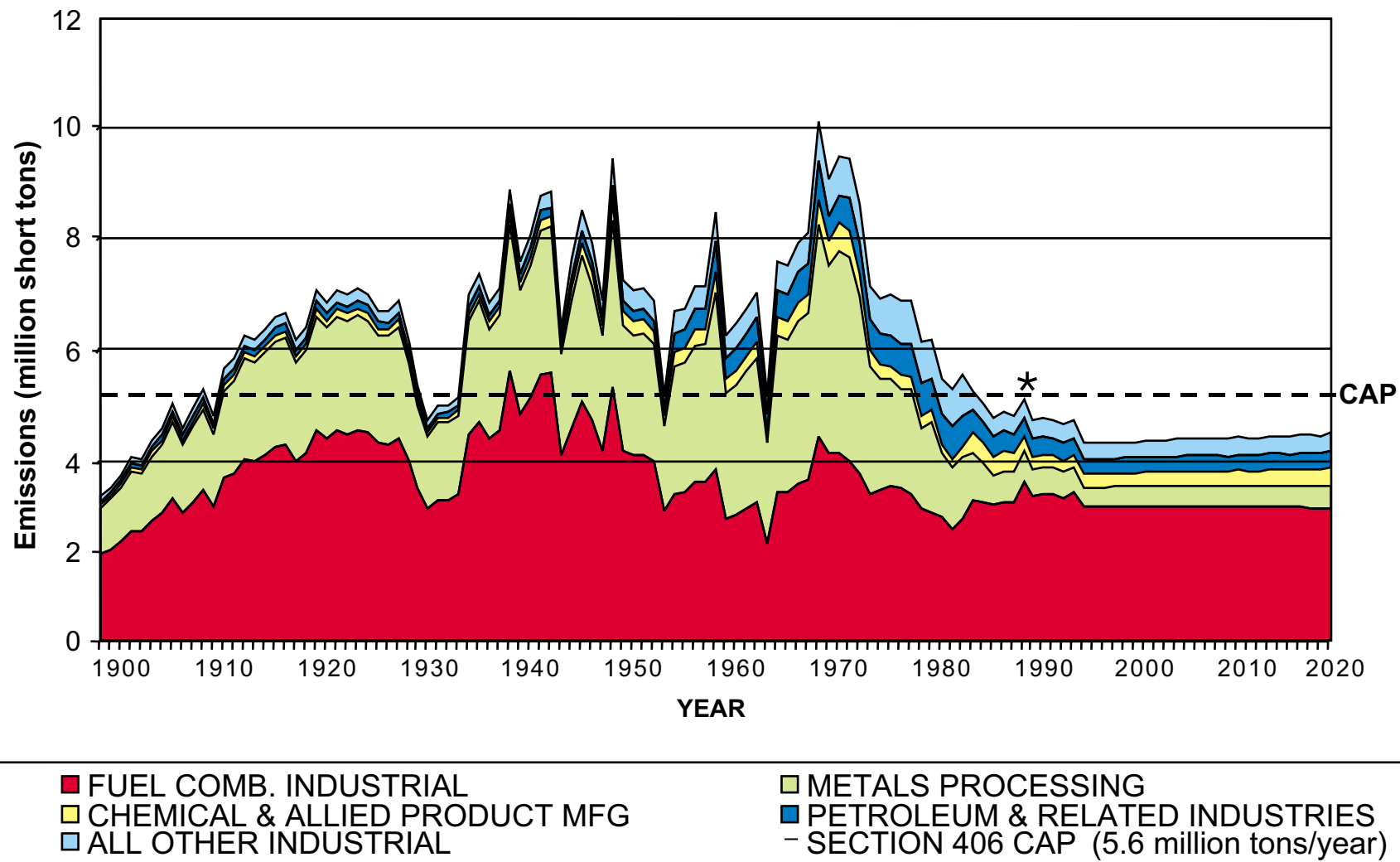
**Table 4-3. Industrial SO₂ Projected Emissions by Selected Source Categories
(thousand short tons)**

Source Category	1996	1999	2002	2005	2007	2008	2011	2014	2017	2020
FUEL COMB. INDUSTRIAL	3,022	3,023	3,024	3,024	3,025	3,022	3,012	3,002	2,993	2,983
Coal	1,465	1,476	1,487	1,498	1,506	1,504	1,499	1,494	1,489	1,484
Oil	844	832	819	807	799	796	788	780	771	763
Gas	556	555	555	554	554	555	558	562	565	568
Other	140	142	145	147	149	149	149	149	149	149
Internal Combustion	17	17	17	18	18	18	18	18	18	18
CHEMICAL & ALLIED PRODUCT MFG	291	301	312	322	329	333	344	356	368	379
Organic Chemical Mfg	4	4	5	5	5	5	5	6	6	6
Inorganic Chemical Mfg	204	212	220	227	233	236	245	254	263	272
Polymer & Resin Mfg	1	1	1	1	1	1	1	1	1	1
Agricultural Chemical Mfg	1	1	1	1	1	1	1	1	1	1
Paint, Varnish, Lacquer, Enamel Mfg	0	0	0	0	0	0	0	0	0	0
Pharmaceutical Mfg	0	0	0	0	0	0	0	0	0	0
Other Chemical Mfg	81	83	85	87	89	90	92	94	97	99
METALS PROCESSING	428	438	447	457	463	467	478	490	501	513
Non-Ferrous Metals Processing	283	295	306	318	325	329	340	351	362	374
Ferrous Metals Processing	128	125	122	120	118	118	117	117	116	116
Metals Processing NEC	17	18	19	19	20	20	21	22	23	23
PETROLEUM & RELATED INDUSTRIES	337	340	343	346	348	351	358	365	372	380
Oil & Gas Production	95	91	87	84	81	80	78	76	73	71
Petroleum Refineries & Related Industries	234	241	247	254	258	261	270	279	289	298
Asphalt Manufacturing	8	8	9	9	9	9	10	10	11	11
OTHER INDUSTRIAL PROCESSES	349	354	359	364	368	370	376	383	389	395
Agriculture, Food, & Kindred Products	4	4	4	5	5	5	5	5	5	5
Textiles, Leather, & Apparel Products	0	0	0	0	0	0	0	0	0	0
Wood, Pulp & Paper, & Publishing Products	102	104	107	109	111	111	113	115	118	120
Rubber & Miscellaneous Plastic Products	0	0	0	0	0	0	0	0	0	0
Mineral Products	230	232	234	235	236	238	241	244	248	251
Machinery Products	0	0	0	0	0	0	0	0	0	0
Electronic Equipment	0	0	0	0	0	0	0	0	0	0
Transportation Equipment	0	0	0	0	0	0	0	0	0	0
Miscellaneous Industrial Processes	13	14	15	16	16	16	17	18	19	19
SOLVENT UTILIZATION	1	1	1	1	1	1	1	1	1	1
STORAGE & TRANSPORT	3	3	3	3	3	3	4	4	4	4
WASTE DISPOSAL & RECYCLING	6	6	7	7	7	7	8	8	9	9
Incineration	6	6	7	7	7	7	8	8	9	9
Open Burning	0	0	0	0	0	0	0	0	0	0
Industrial Waste Water	0	0	0	0	0	0	0	0	0	0
TSDF	0	0	0	0	0	0	0	0	0	0
Landfills	0	0	0	0	0	0	0	0	0	0
All Industrial SO₂ Emissions	4,437	4,466	4,496	4,526	4,545	4,554	4,582	4,609	4,638	4,665

Figure 4-1. SO₂ Emissions by Major Industrial Source Category, 1996



**Figure 4-2. Industrial SO₂ Emissions
(1900 to 2020)**



* Note: Apparent spike in 1990 emissions is due to a methodology shift and should not be interpreted as a 1-year increase in industrial emissions.

Figure 4-3. SO₂ Emissions by Major Industrial Source Category, 2020

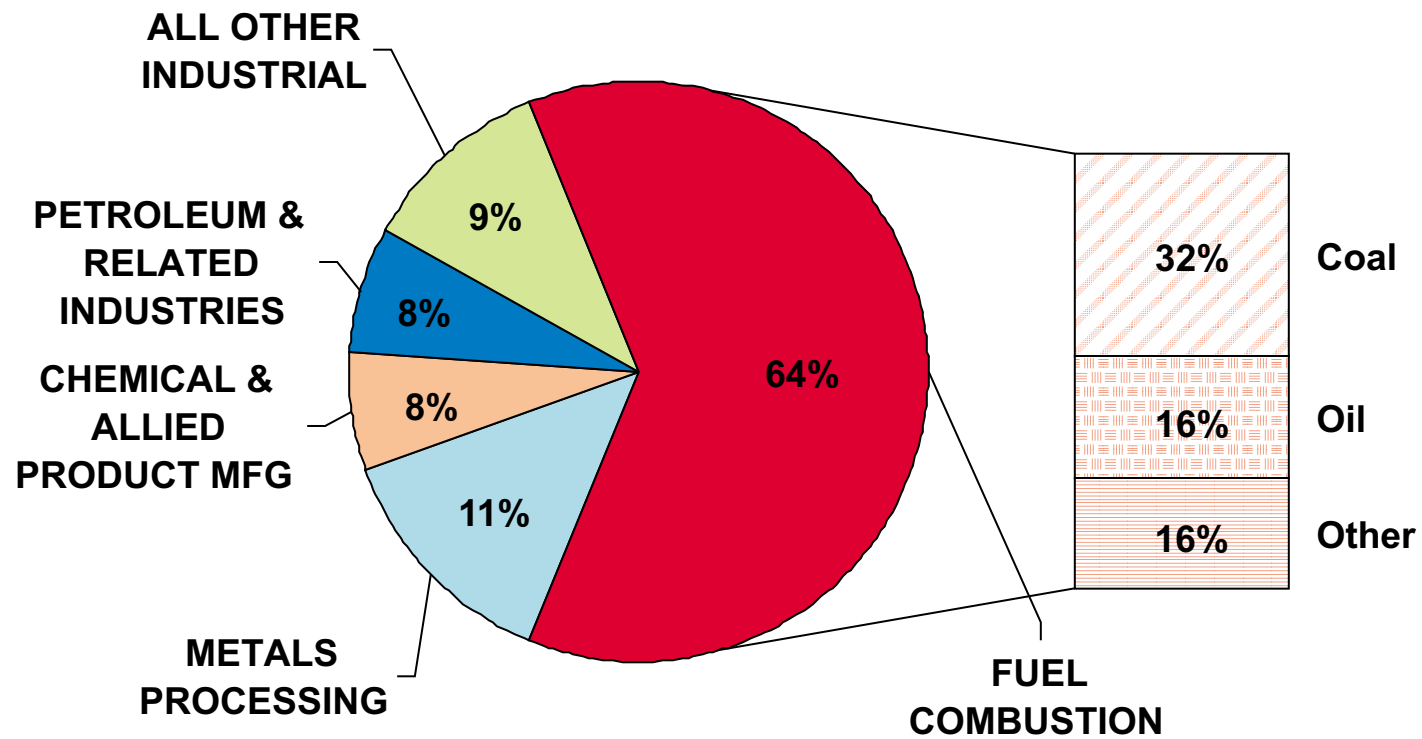
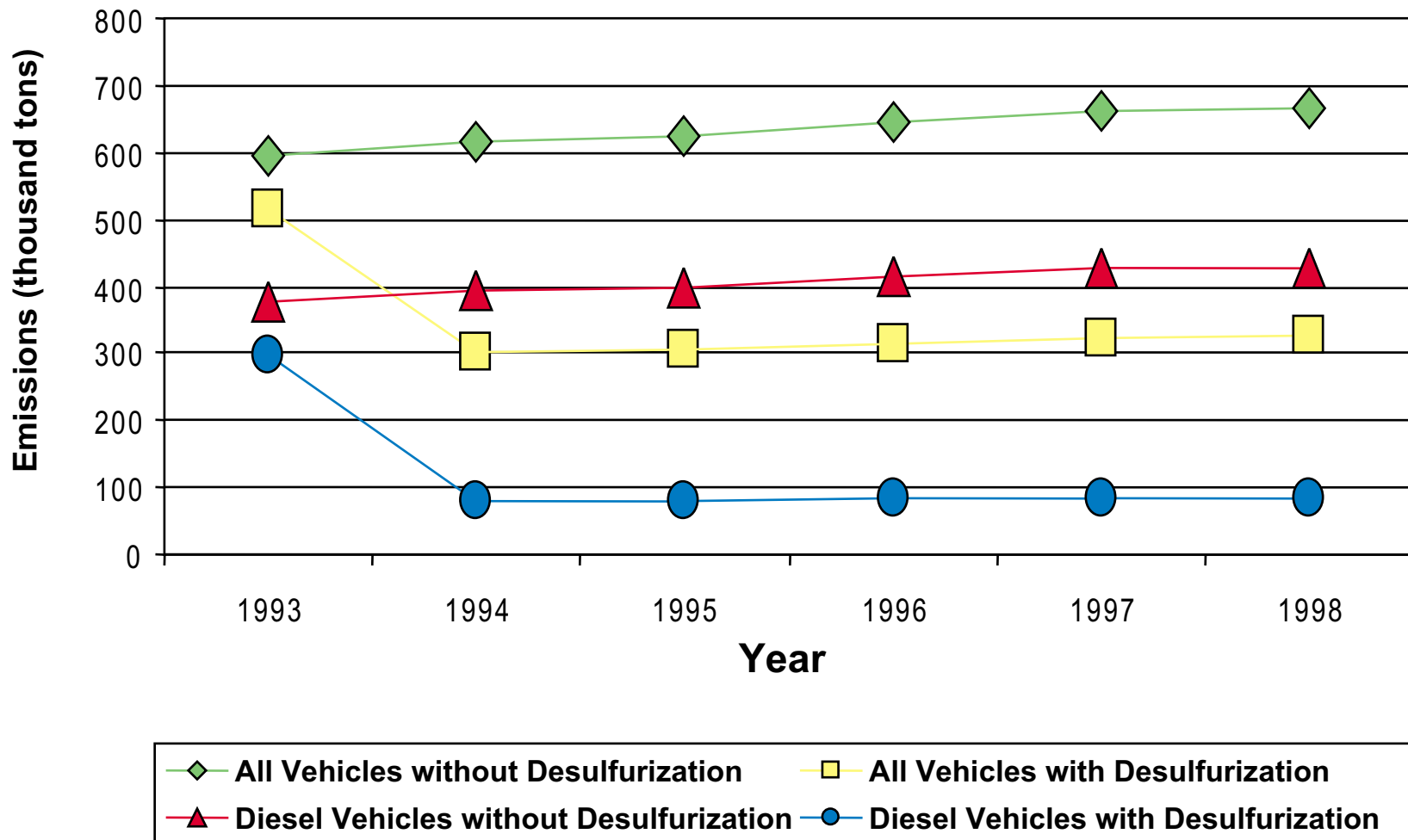


Figure 4-4. SO₂ On-Road Emissions With and Without Desulfurization, 1993-1998



[This page intentionally left blank.]